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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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EASTERN WHITE PINE SEED SOURCE TRIALS: TEN-YEAR RESULTS FROM THREE MIDWESTERN PLANTATIONS

ABSTRACT. — Ten-year-old eastern white pine trees from southern Appalachian sources growing in southern Illinois and southern Indiana are taller and have fewer branches for their size than trees from other sources. In a northeastern Iowa plantation, the "best" seed source is not yet apparent.

OXFORD: 165.53:174.7 *Pinus strobus*. **KEY WORDS: genetic variation, height/diameter ratio, branches per whorl, geographic origin.**

In 1955 the Forest Service and several cooperators began an eastern white pine (*Pinus strobus* L.) provenance study based on seed collected from 31 stands throughout the natural range. Beginning in 1959, at least 22 outplantings were established in 15 States and Provinces, but many plantations did not include trees from all seed sources.

Previous reports have emphasized the generally superior height growth of southern Appalachian white pine in most Midwestern plantations (Funk 1965, Wright 1970). The southern Indiana, southeastern Illinois, and northeastern Iowa test plantings, which include trees from 16 locations selected throughout the natural range of white pine, were remeasured during the 1968 to 1969 dormant season at age 10 (12 years from seed). The trees from Michigan are 1 year younger than the others. The two tallest trees in each of the four-tree plots (12 replications) were measured in Indiana and Illinois, and the five tallest trees in each of the 81-tree plots (four replications) in Iowa. Height, diameter, and number of branches per whorl were measured.

White pines of southern Appalachian origin continued to be taller in Indiana and Illinois, but not necessarily in Iowa (table 1). In Iowa, trees from West Virginia dropped from above to below average height between ages 6 and 10, while those from Wisconsin and Nova Scotia increased to slightly above average. And although northern Georgia white pines were still tallest at age 10, they were only 39 percent taller than the shortest trees, compared with 81 percent taller at age 6. Apparently the Iowa plantation is near the northern limit for superiority of southern Appalachian seed sources. A similar trend toward diminishing differences between northern and southern trees was noticeable in Illinois and Indiana, although trees from the Tennessee source were still about twice as tall as those from Maine in these plantings.

Wright (1970) reported high between-plantation height correlations (mostly between $r = 0.70$ and 0.90) for 16 white pine seed-source plantations in the central and southern States. But the changes in rank correlations of total height among the three plantations reported on here indicate that the high early correlations among all test plantations located south of Minnesota, northern Wisconsin, and northern Michigan may now be breaking down.

Table 1. — *Relative height (seed source mean as a percentage of plantation mean) of white pines from 16 seed sources at ages 6 and 10 years (8 and 12 years from seed)*

Seed source			Plantation location					
No.	Location	North latitude	Illinois		Indiana		Iowa	
			age 6	age 10	age 6	age 10	age 6	age 10
		Degrees						
1	Union Co., Ga.	34.8	129	127	125	120	132	117
2	Transylvania Co., N.C.	35.2	126	116	138	128	100	94
3	Greene Co., Tenn.	36.0	146	133	134	132	136	112
30	Pulaski Co., Va.	37.1	99	95	108	108	100	94
5	Greenbrier Co., W. Va.	38.0	110	101	105	102	109	92
16	Ashland Co., Ohio	40.8	122	114	123	126	105	104
6	Monroe Co., Pa.	41.1	112	112	129	127	127	115
15	Allamakee Co., Iowa	43.5	75	79	88	83	73	91
32	Newaygo Co., Mich.	43.5	--	105	102	112	109	99
20	Luenburg Co., N.S.	44.4	107	112	82	87	95	101
12	Franklin Co., N.Y.	44.4	87	94	76	85	100	104
14	Penobscot Co., Maine	44.9	63	71	69	70	77	94
18	Forest Co., Wis.	45.9	101	103	107	112	95	102
25	Algoma Dist., Ont.	46.2	76	79	78	89	100	99
19	Cass Co., Minn.	47.4	78	88	69	74	73	92
23	Pontiac Co., Quebec	47.5	69	72	66	60	77	84
Mean height, cm.		--	--	448	--	335	--	430
Mean standard error, cm.		--	--	25	--	22	--	27

	Rank correlation coefficient (r_s) *for total height at plantation age:*	
Correlation between	*6 years*	*10 years*
Indiana and Illinois	+0.87	+0.91
Indiana and Iowa	+ .66	+ .63
Illinois and Iowa	+ .77	+ .65

The relative decline in correlation between the Iowa plantation and the other two, which are approximately 375 miles to the south, suggests that performance in northeastern Iowa may eventually be quite different from that in southern Indiana and Illinois.

Wright (1970) suggested that height and diameter growth capacity may be inherited separately in white pine. My data seem to support this hypothesis, because trees from many southern provenances yielded consistently low h/d ratios, while those from others, such as Iowa, Minnesota, and Quebec, were high (table 2). Indeed, analysis of variance indicated that the h/d ratio varies with seed source (significant at the 0.02 level). But the h/d ratio turned out to be strongly correlated with diameter, with r values of —0.82 for the Illinois plantation, —0.93 for Indiana, and —0.87 for Iowa. About 75 percent of the total variation in h/d ratio is thus explained by diameter variation alone. But a similar analysis of Wright's (1970) data from the Kellogg Forest plantation in Michigan shows a correlation between h/d and diameter of only —0.39, so the possibility of independent inheritance of height and diameter growth must still be considered. For the three plantations reported on here, it appears that recording of diameter alone should be sufficient for the next few data collections. It should not be necessary to make time-consuming height measurements more often than once each 10 years.

Possible genetic variation in number of branches per whorl is of interest, because pruning time per tree is roughly proportional to the number of branches removed (Ralston and Lemmien 1956). In a

Table 2. — *Height/diameter ratio (seed source mean as percent of plantation mean) of trees from 10-year-old white pine plantations*

Seed source		Plantation location		
No.	Location	Illinois	Indiana	Iowa
1	Ga.	91	82	91
2	N. C.	93	81	104
3	Tenn.	81	81	96
30	Va.	93	90	96
5	W. Va.	95	85	103
16	Ohio	96	83	97
6	Pa.	91	86	98
15	Iowa	107	121	108
32	Mich.	98	86	97
20	N. S.	88	106	103
12	N. Y.	102	91	97
14	Maine	139	131	101
18	Wis.	102	90	101
25	Ont.	109	116	97
19	Minn.	113	124	107
23	Quebec	104	147	105
Plantation mean (cm./cm.)		68	101	68
Mean standard error		3.8	6.8	2.9

study of open-pollinated progeny from six selected loblolly pine (*P. taeda* L.) parent trees, the average number of branches per whorl ranged from 3.5 to 4.6, with each family having "a marked trend to form a given number of branches per whorl" (von Wedel, Zobel and Shelbourne 1968). On the other hand, Nanson (1969) studied Scotch pine (*P. sylvestris* L.) seedlings families in Belgium and found no differences in branch number related to parent stands or seed trees within stands. Our measurements were complicated by the fact that eastern white pine tends to produce lateral branches of two distinct sizes. For instance, in the third youngest whorl of branches, most are either more than 1.7 cm. in diameter (main branches) or less than 0.8 cm. (secondary) when measured at a point 2 cm. from the bole (fig. 1). The secondary branches easily fit the definition given by von Wedel, Zobel and Shelbourne (1968): "having a diameter less than one-half of the diameter of the largest branch in the whorl." We tallied the number of main branches in the third whorl, but analysis of variance indicated no significant differences among

F-520702

Figure 1. — *A whorl of white pine branches showing two distinct size classes.*

the seed sources. I also tabulated total number of branches (main plus secondary) for the Illinois plantation with similar results. But the number of branches per whorl is related to tree height ($r = +0.58$) and d.b.h. ($r = +0.63$), and number of branches per unit area of bole surface is probably more meaningful than total number. Seed source means for number of branches per whorl divided by d.b.h. are given in table 3; analysis of variance shows that this value also varies with seed source (significant at the 0.01 level). Among the seed sources that produced the larger trees — 1, 2, 3, 16, and 6 — the first three stand out as being distinctly less branchy.

To verify the apparently good branching habit of the Georgia, North Carolina, and Tennessee white pines, I made a similar analysis of data from a 1966 measurement of the Illinois plantation and a 1965 measurement of a southern Ohio outplanting. In these measurements, branches were counted in the second whorl from the top; their number was closely related to height ($r = +0.85$), but diameter was not recorded because some of the smaller trees had not grown to 4.5 feet. The same five seed sources that produced the largest diameter trees at age 10 also produced the tallest trees in the 7- and 8-year-old plantations. Differences in branch number divided by total height proved to be highly significant. Seed sources 1, 2, and 3 once again were characterized by trees with fewer branches per whorl (5.9 to 7.1) in contrast to sources 6 and 16, which averaged more than 7.4 branches (near the overall mean).

Table 3. — *Number of branches per centimeter of diameter in trees from 10-year-old white pine plantations*

Seed source		Plantation location			Seed source
No.	Location	Illinois	Indiana	Iowa	mean
1	Ga.	0.98	1.26	1.30	1.18
2	N. C.	.79	1.06	1.18	1.01
3	Tenn.	.94	1.30	1.22	1.15
30	Va.	1.18	1.57	1.57	1.44
5	W. Va.	1.10	1.69	1.77	1.52
16	Ohio	1.10	1.69	1.61	1.47
6	Pa.	1.18	1.65	1.42	1.42
15	Iowa	1.38	2.56	1.73	1.89
32	Mich.	1.14	1.65	1.54	1.44
20	N. S.	1.06	2.40	1.77	1.74
12	N. Y.	1.38	2.09	1.50	1.66
14	Maine	1.81	2.91	1.93	2.22
18	Wis.	1.22	1.54	1.50	1.42
25	Ont.	1.42	2.91	1.54	1.96
19	Minn.	1.30	2.72	1.65	1.89
23	Quebec	1.42	3.27	2.05	2.25
Plantation mean		1.21	2.02	1.58	--
Mean standard error		.12	.19	.12	--

The genetic variation reported here seems to offer a good opportunity to select white pine of southern Appalachian origin for high-volume production and reduced branchiness at the same time. It also may be possible to select and breed white pine Christmas trees that combine slower growth rate with numerous branches. Although there is still doubt as to which provenances are best suited for use in Iowa and areas farther north, it appears that the southern Appalachian region is a good seed source for Ohio Valley white pine plantations. The possibility of exploiting additional genetic variation associated with individual parent trees should be investigated — either by making single-tree seed collections within the southern Appalachian area, or by producing control-pollinated seed in the existing provenance research plantations.

LITERATURE CITED

Funk, D. T. 1965. Southern Appalachian white pine off to a good start in the Midwest. Cent. States Forest Tree Impr. Conf. 4: 26-28.

Nanson, Alphonse. 1969. Tests de descendances de Pin Sylvestre. Trav. Sta. Rech. Eaux et Forets, Ser. E, No. 3, 52 p. illus.

Ralston, Robert A., and Lemmien, Walter. 1956. Pruning pine plantations in Michigan. Mich. Agr. Exp. Sta. Circ. Bull. 221, 27 p., illus.

Wedel, K. W. von, Zobel, B. J., and Shelbourne, C. J. A. 1968. Prevalence and effects of knots in young loblolly pine. Forest Prod. J. 18(9): 97-103, illus.

Wright, J. W. 1970. Genetics of eastern white pine (*Pinus strobus* L.). USDA Forest Serv. Res. Pap. WO-9, 16 p., illus.

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